

We claim:

- 1 1. A nanowire strain gauge comprising:  
2 a piezoresistive wire having a cross sectional area of the order of  $100 \text{ nm}^2$  or  
3 less; and  
4 means for measuring resistance change in the piezoresistive wire in response to  
5 a transverse force applied to the piezoresistive wire.
- 1 2. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises a  
2 free standing nanowire clamped at opposing ends.
- 1 3. The nanowire strain gauge of claim 2 further comprising a biofunctionalized  
2 element suspended by and connected to the free standing nanowire.
- 1 4. The nanowire strain gauge of claim 1 further comprising a flexure element and  
2 where the piezoresistive wire comprises an embedded piezoresistive wire in the flexure  
3 element.
- 1 5. The nanowire strain gauge of claim 4 where the flexure element comprises at  
2 least one arm in a notched nanocantilever.

1 6. The nanowire strain gauge of claim 1 further comprising a flexure element and  
2 where the piezoresistive wire comprises an array of piezoresistive wires embedded in  
3 the flexure element.

1 7. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises a  
2 thin metal film.

1 8. The nanowire strain gauge of claim 7 where the thin metal film comprises a film  
2 with a thickness of the order of tens of angstroms or less.

1 9. The nanowire strain gauge of claim 7 where the thin metal film has a thickness  
2 such that the film comprises a discontinuous metal island structure.

1 10. The nanowire strain gauge of claim 8 where the thin metal film comprises a pure  
2 metal composition selected from the group consisting of Au, Cr, Ag, Pd, Ni, Pt, Mn and  
3 alloys, Au-Ni, NiCr, Bi-Sb, Ag-Ni, Cu-Ni, and Pt-Cr.

1 11. The nanowire strain gauge of claim 4 where the piezoresistive wire comprises a  
2 thin metal film included in a bimorph structure comprised of a top layer comprised of the  
3 thin metal film and a bottom layer comprised of a higher resistive metal layer than the  
4 top layer, a semiconductor layer or an insulating layer.

1 12. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises  
2 doped crystalline silicon.

1 13. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises  
2 doped silicon carbide.

1 14. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises  
2 doped GaAs.

1 15. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises  
2 doped  $\text{Ga}_x\text{Al}_{1-x}\text{As}$ , where  $0 < x < 1$ .

1 16. The nanowire strain gauge of claim 1 where the piezoresistive wire comprises a  
2 doped AlGaN/GaN, AlN/GaN/InN or GaN/AlN/GaN heterostructure.

1 17. A nanowire strain gauge comprising:  
2 a free standing piezoresistive nanowire having a cross sectional area of the order  
3 of  $100 \text{ nm}^2$  or less and clamped at opposing ends; and  
4 means for measuring resistance change in the piezoresistive wire in response to  
5 a transverse force applied to the piezoresistive wire.

1 18. The nanowire strain gauge of claim 17 further comprising a biofunctionalized  
2 element suspended by and connected to the free standing nanowire.

1 19. The nanowire strain gauge of claim 17 where the piezoresistive wire comprises a  
2 thin metal film with a thickness of the order of tens of angstroms or less, doped  
3 crystalline silicon, doped silicon carbide, doped GaAs, doped  $\text{Ga}_x\text{Al}_{1-x}\text{As}$ , where  $0 < x <$   
4 1, or a doped AlGaN/GaN, AlN/GaN/InN or GaN/AlN/GaN heterostructure.

1 20. A nanowire strain gauge comprising:  
2 a flexure element;  
3 a piezoresistive wire embedded in the flexure element, the piezoresistive wire  
4 having a cross sectional area of the order of  $100 \text{ nm}^2$  or less;  
5 means for measuring resistance change in the piezoresistive wire in response to  
6 a transverse force applied to the piezoresistive wire.

1 21. The nanowire strain gauge of claim 20 further comprising a plurality of  
2 piezoresistive wires forming an array of embedded piezoresistive wires in the flexure  
3 element.

1 22. The nanowire strain gauge of claim 20 where the piezoresistive wire comprises a  
2 thin metal film included in a bimorph structure comprised of a top layer comprised of the  
3 thin metal film and a bottom layer comprised of a higher resistive metal layer than the

4 top layer, a semiconductor layer or an insulating layer, doped crystalline silicon, doped  
5 silicon carbide, doped GaAs, doped  $\text{Ga}_x\text{Al}_{1-x}\text{As}$ , where  $0 < x < 1$  or a doped  
6 AlGaN/GaN, AlN/GaN/InN or GaN/AlN/GaN heterostructure.

1 23. A method of measuring strain at nanoscales comprising:  
2 providing nanowire strain gauge comprised of a piezoresistive wire having a  
3 cross sectional area of the order of  $100 \text{ nm}^2$  or less;  
4 stressing the piezoresistive wire with a force having a transverse component; and  
5 measuring resistance change in the piezoresistive wire in response to the  
6 transverse component of the force applied to the piezoresistive wire.

1 24. The method of claim 23 where providing nanowire strain gauge comprised of a  
2 piezoresistive wire comprises providing a free standing nanowire clamped at opposing  
3 ends and where stressing the piezoresistive wire comprises applying the force to the  
4 nanowire between the opposing ends.

1 25. The method of claim 24 further comprising reacting a biofunctionalized element  
2 suspended by and connected to the free standing nanowire with a target molecule,  
3 oscillating the nanowire at a resonant frequency, and measuring modification of the  
4 resonant frequency of the nanowire due to the reaction with the target molecule.

1 26. The method of claim 13 further comprising providing a flexure element in which  
2 the piezoresistive wire comprises an embedded piezoresistive wire so that stressing the  
3 piezoresistive wire comprises stressing the flexure element.

1 27. The method of claim 26 where providing a flexure element comprises providing  
2 at least one arm in a notched nanocantilevers to serve as the flexure element.

1 28. The method of claim 23 further comprising providing a flexure element and where  
2 the piezoresistive wire further comprises an array of piezoresistive wires embedded in  
3 the flexure element.

1 29. The method of claim 23 where providing nanowire strain gauge comprised of a  
2 piezoresistive wire comprises a thin metal film.

1 30. The method of claim 29 where providing the thin metal film comprises providing a  
2 film with a thickness of the order of tens of angstroms or less.

1 31. The method of claim 29 where providing the thin metal film provides a film with a  
2 discontinuous metal island structure.

1 32. The method of claim 30 where providing the thin metal film comprises providing a  
2 film with a pure metal composition selected from the group consisting of Au, Cr, Ag, Pd,  
3 Ni, Pt, Mn and alloys, Au-Ni, NiCr, Bi-Sb, Ag-Ni, Cu-Ni, and Pt-Cr.

1 33. The method of claim 26 where providing the piezoresistive wire comprises  
2 providing a thin metal film included in a bimorph structure comprised of a top layer  
3 comprised of the thin metal film and a bottom layer comprised of a higher resistive metal  
4 layer than the top layer, a semiconductor layer or an insulating layer.

1 34. The method of claim 23 where providing the piezoresistive wire comprises  
2 providing doped crystalline silicon.

1 35. The method of claim 23 where providing the piezoresistive wire comprises  
2 providing doped silicon carbide.

1 36. The method of claim 23 where providing the piezoresistive wire comprises  
2 providing doped GaAs.

1 37. The method of claim 23 where providing the piezoresistive wire comprises  
2 providing doped  $\text{Ga}_x\text{Al}_{1-x}\text{As}$ , where  $0 < x < 1$ .

- 1 38. The method of claim 23 where providing the piezoresistive wire comprises
- 2 providing a doped AlGa<sub>N</sub>/Ga<sub>N</sub>, AlN/GaN/InN or GaN/AlN/GaN heterostructure.